P-196

9 November 1956

MEMORANDUM FOR: THE RECORD

SUBJECT: Liaison Visit to WADC/Weapons Guidance Laboratories

1. The undersigned visited the Tactical Branch of the Weapons Guidance Laboratories in order to be briefed on the current status of all Air Force projects concerned with or applicable to terrain guidance/obstacle warning systems. Pertinent projects, with a short description of each, are listed below:

a. Cornell Aeronautical Laboratory has developed hardware for a system known as "Pee-Vee", which is a mono-pulse, X-band radar plotting range vs. elevation or azimuth vs. elevation. It uses a 24" parabolic dish antenna (APG/46 type). The equipment weighs approximately 150 pounds. Due to a lack of funds, this project will be terminated upon conclusion of the present development phase.

b. North American Aviation is pursuing a study of means for modifying the APS/23 X-band system. The modification has as its objective the alteration of the APS/23 for mono-pulse operation yielding a range vs. azimuth plot on the indicated scope. Since this program is at this time only a study phase, it is somewhat difficult to judge the potential application of such a system should it prove feasible in the first place.

c. A breadboard auxiliary indicator for the APS/23 system is being designed by General Mills. It's sole function will be to provide an indication to the operator of the equipment that a given target on the scope is either increasing or decreasing in range.

d. The University of Illinois is working on a 2-color system which will provide in red target information on the scope face if it is above the flight path line. This will otherwise be a normal PPI presentation operating at X-band.

e. The Westinghouse XMA-1 terrain avoidance system program is grinding to a slow but sure halt, again due to a lack of funds within the Air Force. The project engineer, [redacted], stated that he felt this system showed the most potential and that if the 25X1

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decision were up to him, he would recommend the [redacted] above all others at this time. [redacted] is currently completing a breadboard phase of this program for the Air Force and commencing in mid-December will institute a flight test program which will include all currently completed hardware. [redacted] has on hand now a proposal from [redacted] for a study of a new antenna system utilizing ferrites if possible. The present antenna is a 10' linear array - far too large for most aircraft. 25X1 25X1 25X1 25X1

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Distribution:
- Orig. - P-196
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Lt. Col. Daniel F. Shea

c/ Tactical Br/ NGL

$80,000

PROPOSED ANTENNA DEVELOPMENT PROGRAM

FOR

XMA-1 TERRAIN AVOIDANCE SYSTEM

## SCOPE

This proposal presents a three-part program for obtaining a practical antenna system for use with the flyable model Terrain Avoidance System. 25X1 This equipment is presently being built under Contract 25X1

The presently used antenna system was chosen for its straight-forward electrical nature, utilizing known antenna techniques, the primary purpose of the program being to check the feasibility of the overall system. This antenna system is adequate and suitable for the flight test program of the system. It is, 25X1 however, large and awkward to reconcile with airframe design of high speed aircraft for which terrain avoidance equipment is ultimately intended.

The major object of the proposed program is to achieve an antenna system reconciling airframe and electrical requirements insofar as practicable.

## GENERAL DESCRIPTION OF PROGRAM

### Subdivision by tasks

A three part program is proposed consisting of the following three phases: (1) Study, (2) Design, (3) Construction and flight test. It is suggested that the first phase, the Study portion of the program, be considered a definite task to be accomplished in its entirety. The two remaining phases would be considered as additional tasks to be undertaken if the Phase 1 task yields results indicating it is advisable to proceed with design, construction, and flight testing.

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PHASE 1: STUDY

Results of the flight test program of the [redacted] Terrain Avoidance project 25X1 would serve to establish the general parameters for the antenna system discussed in this proposal. A detailed study would be made of all work in the field of antenna design which may be applicable to Terrain Avoidance Systems. Some antenna projects underway may be far from complete as regards the specific aims of the individual project, however, parts of the program may be readily applicable to the Terrain Avoidance problem. An example is a program wherein an effort is made to attain reciprocal directivity of a ferrite antenna for transmitting and receiving so that it can be used for search or tracking radar. This reciprocal directivity problem is of no consequence in a terrain avoidance system when using separate antennae for transmitting and receiving.

In general, the antenna problem is primarily one of determining the most practical method of providing a given antenna aperture. Using standard single frequency radar techniques, as in the XMA-1 system, once the resolution parameters are chosen, the antenna aperture is quite closely defined.

Should a 6 foot aperture prove advisable, then a 6 foot projected dimension must be accommodated on the airframe, whether this be achieved by contoured elements flush-mounted on the surface of the aircraft or by more conventional linear or dish reflector elements mounted within a radome.

The contour type is most economical in employment of aircraft volume. This method ordinarily requires the use of phase-shift or frequency-shift scanning, involving considerable electrical complexity and precision in construction. The more conventional radome enclosed design can be made more straight-forward

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electrically but high speed mechanical scanning becomes awkward. Also, considerable aircraft volume must be sacrificed, especially in the case of long pointed nose aircraft.

It is to the study of techniques and combinations of methods to most suitably accomplish the required scanning within the limits of practical utilization of space in the aircraft, that this program is directed. The following discussion covers some antenna techniques which may be considered during the study phase of the program.

Figure 1 illustrates the general scanning pattern desired. The scanning antenna system can be made up of various combinations of the following methods.

Some beam forming methods:

1. A point source illuminating a reflector, such as a spun metal parabolic dish.
2. A point source feeding a plastic lens.
3. A series of discrete sources fed by a transmission line. Examples are the various type of bedspring arrays, the old "Eagle" linear array, and the surface-slot dielectric waveguide combination.

Some beam scanning methods:

1. Mechanical movement of the entire antenna structure. This is normally employed with tracking radar systems.
2. Mechanical movement of a point source with respect to a fixed reflector or lens. Examples would be a wobbled horn feeding a parabolic reflector or a luneberg lens.

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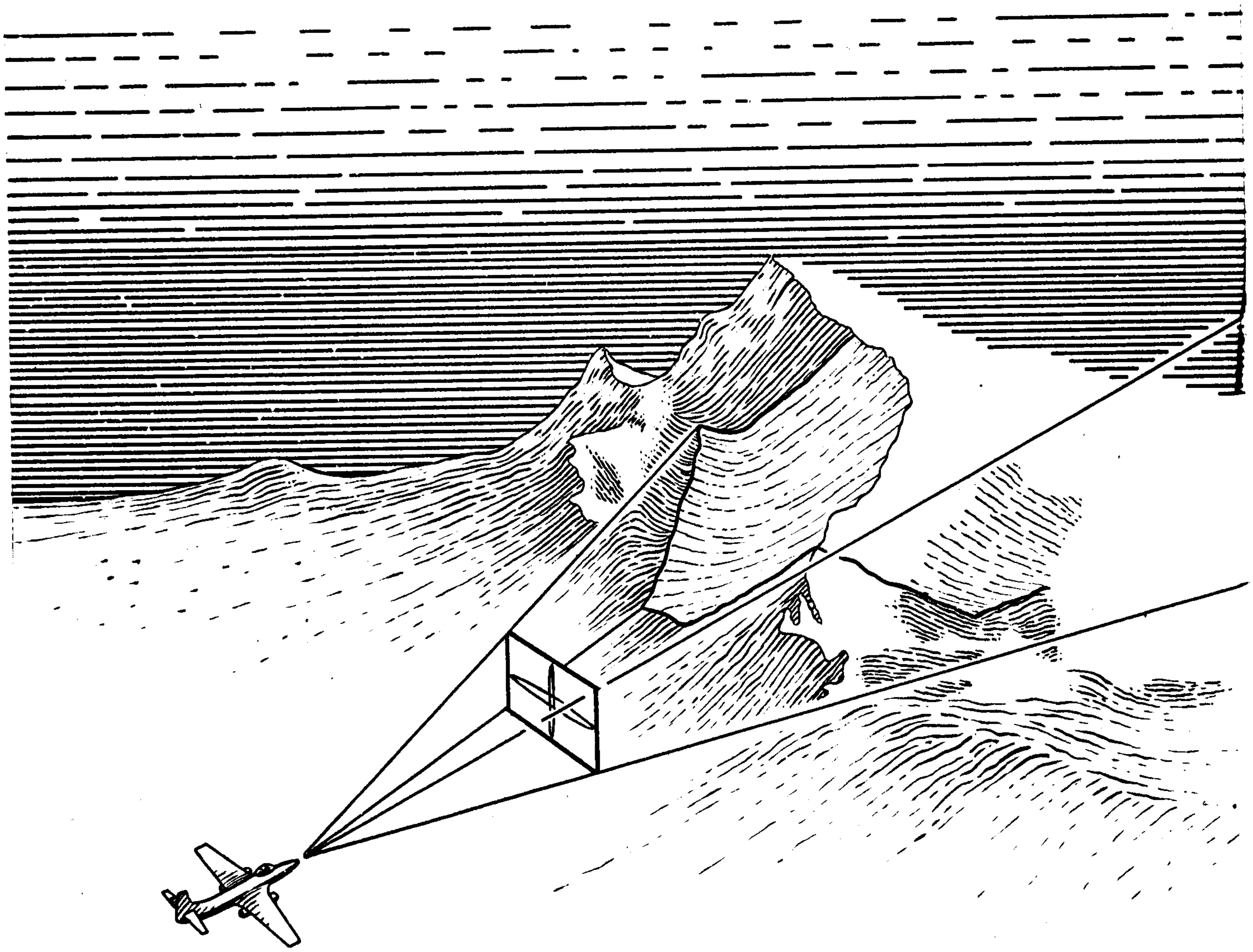

FIG. 1 - General Pattern of Scanning Coverage required for Terrain Avoidance System.

3. Mechanically induced phase shift of power fed to discrete sources. An example is the [redacted] horizontal antenna using a slotted waveguide antenna 25X1 with a moving back wall.

4. Electrically induced phase shift of power fed to discrete sources. A slotted line antenna filled with ferrite, magnetically modulated will produce this effect.

5. Frequency shift of power fed to discrete sources. This requires a variable frequency source such as a travelling wave tube.

Following are several of the antenna system combinations which could be considered during the study phase of the project.

1. An elliptical parabolic reflector fed by a trapezoidal horn as shown in Figure 2. The elliptical shape of the reflector would be determined by the desired antenna pattern, narrow vertically and broader horizontally. This would mean that the major dimension of the elliptical reflector would be vertical. The array would be rotated about the vertical axis to produce azimuth scanning of $\pm 15^{\circ}$ at a rate of approximately 1/2 cycle per second. A rotating waveguide feed to a rolled trapezoidal horn would produce vertical scanning at approximately 50 cycles per second.

   The chief advantage of this method is the high antenna gain resulting from concentrating the transmitting antenna output power into a pencil beam. Functionally this system is straight-forward using standard techniques. Disadvantages are the large volume occupied and the large mechanical forces involved in the high speed of scanning required.

2. Use of two slotted waveguide arrays with moving back walls to provide

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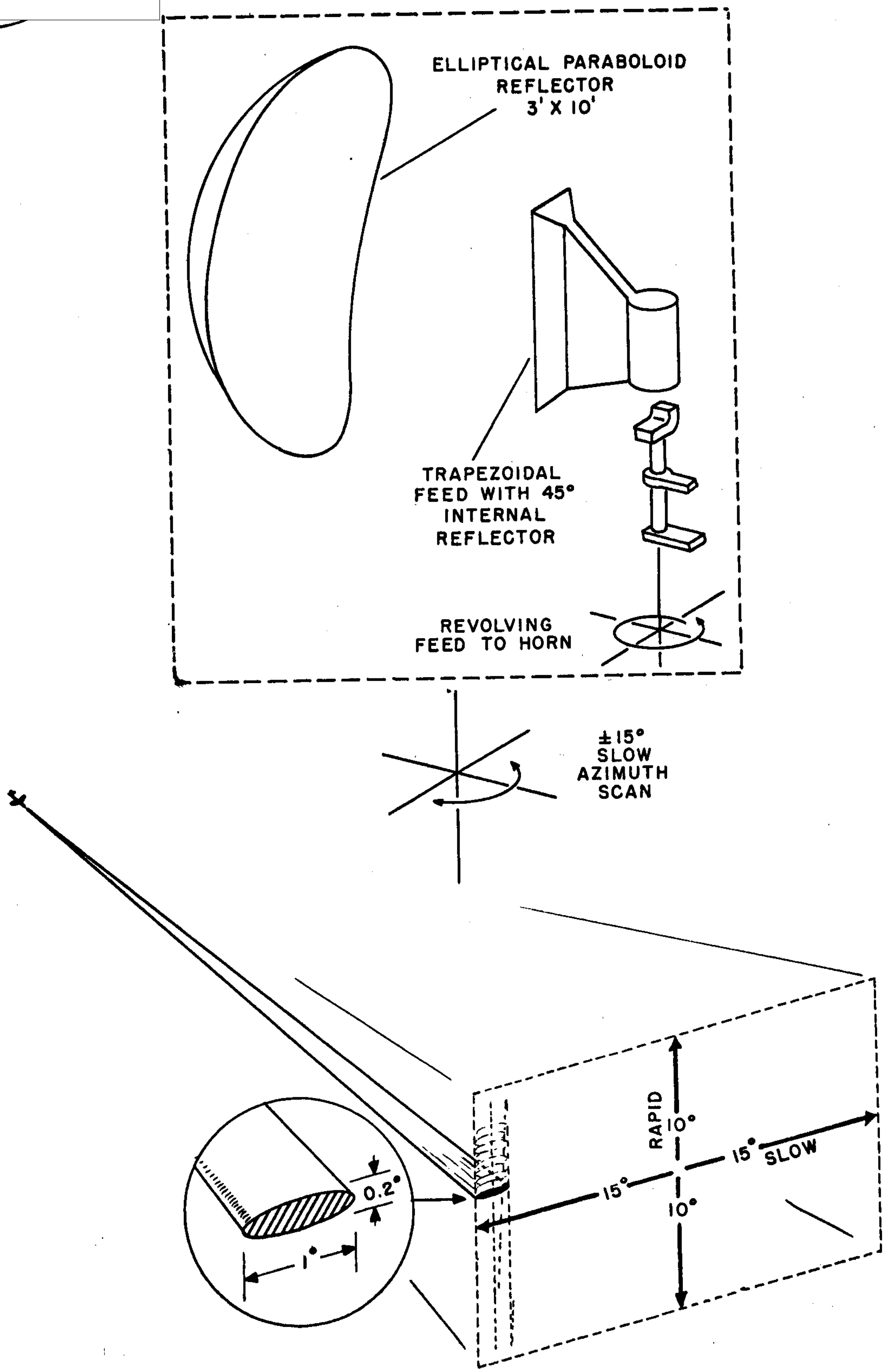


FIG. 2 - Single Pencil Beam Scanning

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phase shift. See Figure 3. One array would be used for transmitting a fan-shaped beam in the vertical plane. The other array would serve as the receiving antenna with a fan-shaped pattern in the horizontal plane. By applying scanning to both arrays, the resultant is the equivalent of a pencil beam.

The mechanical excursion required of the back wall is very small, but great precision of machining is required.

3. Frequency shift scanning with a slotted waveguide array for transmitting and a non-frequency sensitive paraboloid reflector for receiving. See Figure 4. The frequency shift scanning could be accomplished at a high rate on the order of 50 cycles per second, while the slow 1/2 cycle scan could be performed by oscillating the paraboloid-and-horn array. The major problem is the lack of a variable-frequency, high-power transmitting tube. Future development of traveling wave tubes, however, may make this method feasible. One advantage is the fact that a very light weight array could be designed using a slotted waveguide element or an etched surface slot type.

4. Phase shift scanning by means of ferrite linear arrays. See Figure 5. Two arrays at right angles would be used, one for transmitting, another for receiving. The great advantage of this technique is the lack of any moving parts. From a practical standpoint the chief difficulty is the required constancy of effective waveguide cross-section. The waveguide must be of a mechanically constant cross-section. The ferrite must be of consistant quality, dimensions, and placement. The applied magnetic field must be homogeneous.

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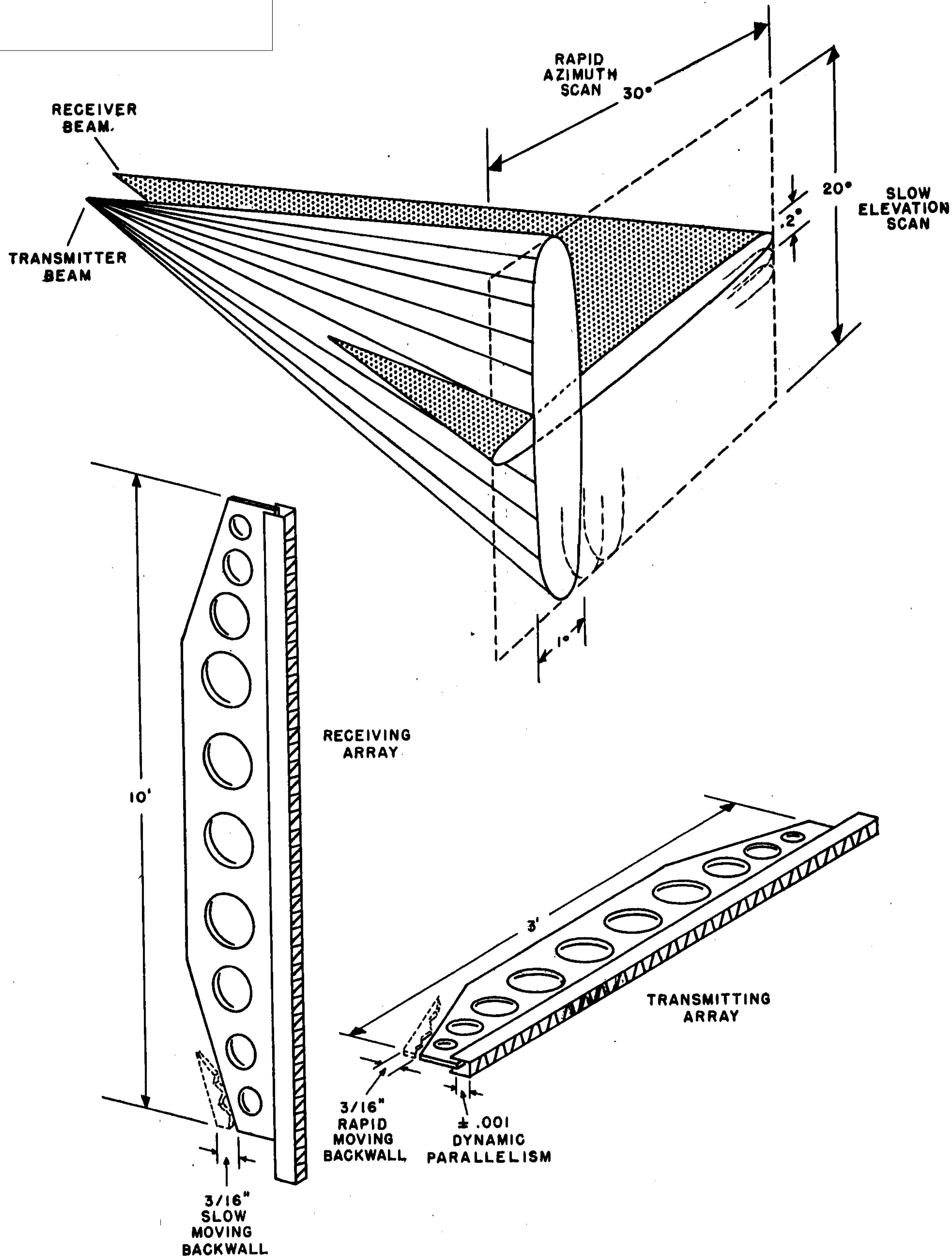


Fig. 3 - Phase-Shift Scanning

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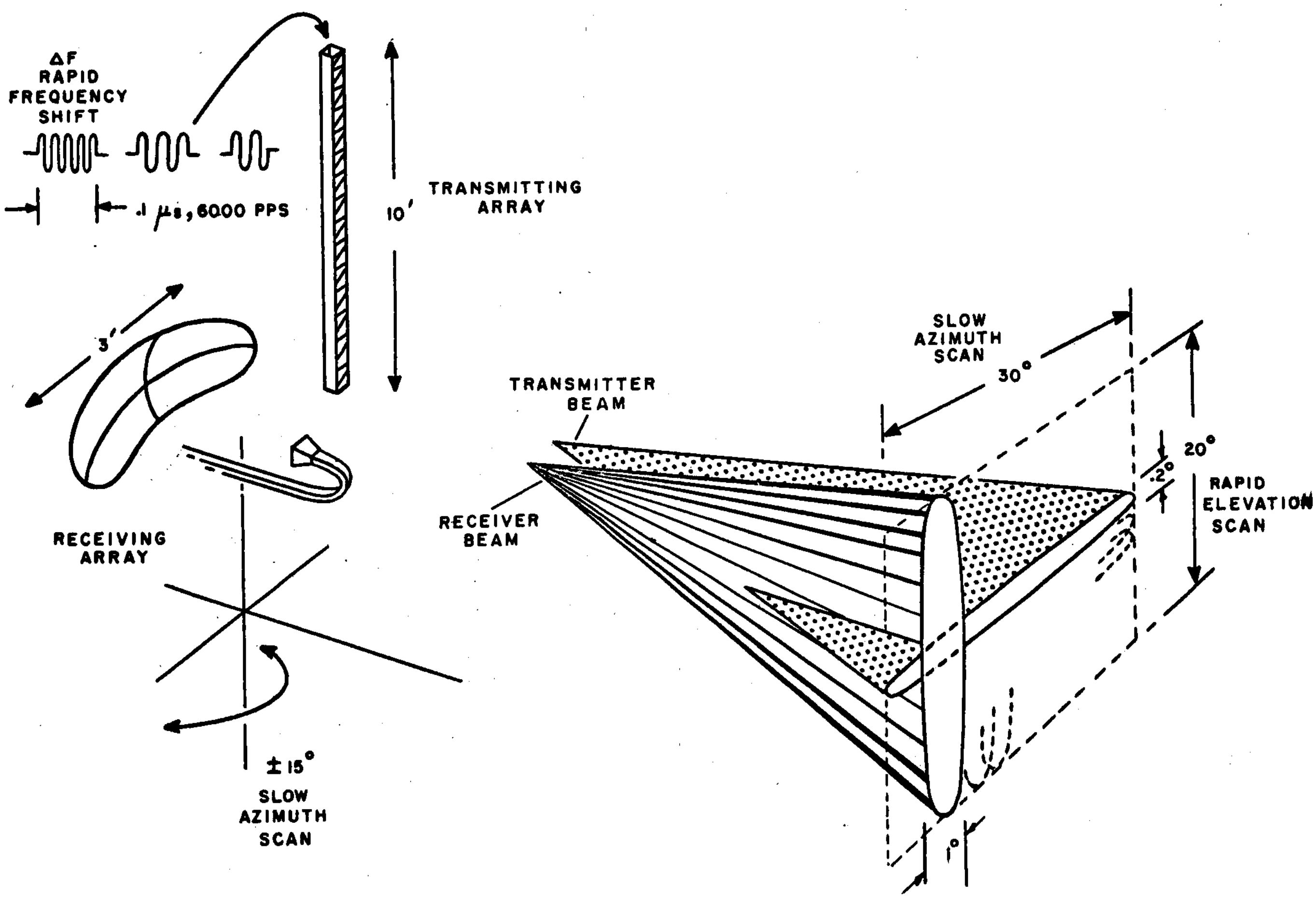


Fig. 4 - Frequency-Shift Scanning

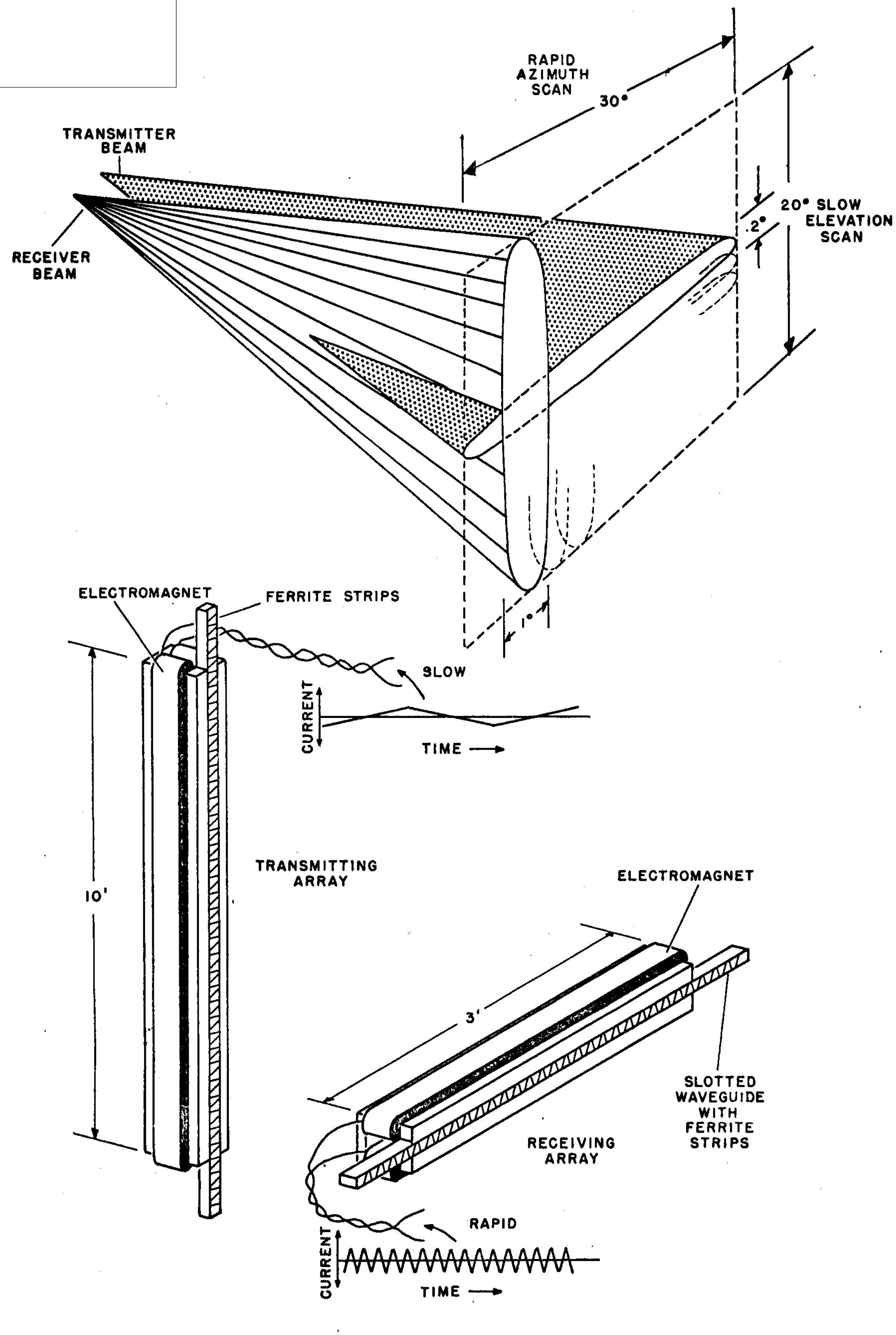


Fig. 5 - Ferrite Phase-Shift Scanning

The scanning systems illustrated utilize an effective beam of 1° in azimuth by .2° in elevation as used in the present [redacted] equipment. 25X1 Evaluation of the results of the flight test program will determine to what extent the antenna dimensions can be reduced.

PHASE 2: DESIGN

From the results of the study phase, the most promising techniques and methods will be selected to arrive at a coordinated antenna system suitable for use with the flyable model of the XMA-1 equipment.

The design will be made to fit a simulated nose section of a high-speed low-altitude aircraft such as the B-66. A complete set of drawings suitable for Model Shop construction of the antenna will be provided. Design will be suitable for mounting in an aircraft for flight testing. MIL-E-5400 will be used as a guide in all design work to minimize subsequent modifications should it be desirable to carry on a development or prototype model program.

PHASE 3: CONSTRUCTION AND FLIGHT TEST

A model of the antenna system will be constructed and made ready for flight test with the flyable model of the XMA-1 equipment. A brief bench test will be made prior to mounting on a test vehicle such as the B-17 into which the XMA-1 equipment is presently being installed.

A flight test program of 10 - 15 hours flying time is considered suitable to check the system operation using the new version of antenna.